



Power to the People

Teller's Contributions to Nuclear Power Research

January 15, 2008, marks the 100th anniversary of Edward Teller's birth. This highlight is the ninth in a series of 10 honoring his life and contributions to science.

WHEN nuclear fission was discovered in 1939, Edward Teller saw its enormous potential for both military and civilian uses. In particular, he and others recognized that nuclear power offered a potentially clean and inexpensive alternative to other sources of energy. Likewise, his lifelong interest in fusion led the Laboratory to establish a fusion energy program, which continues today.

Teller realized that the 21st century would present serious energy-related issues. The developing world would significantly increase its energy consumption as its standard of living rose. Burning fossil fuels to meet that demand would likely exhaust the world's petroleum supplies and could cause dangerous levels of pollution. Later in Teller's life, scientists began to acknowledge that large-scale fossil-fuel consumption increased the atmospheric concentration of carbon dioxide, leading to dramatic climate changes. In *Memoirs*, Teller noted that, "Alternative energy sources, such as wind power and solar energy, are not quantitatively significant." He thus saw nuclear power as a key option for the long term.

While working at Los Alamos National Laboratory, Teller contributed to some of the early reactor projects, and in 1947, he became the first chairman of the Atomic Energy Commission's (AEC's) Committee on Reactor Safeguards. Far ahead of his time in stressing reactor safety, he guided the committee to develop an approach for including accident probabilities when designing a reactor's safety features.

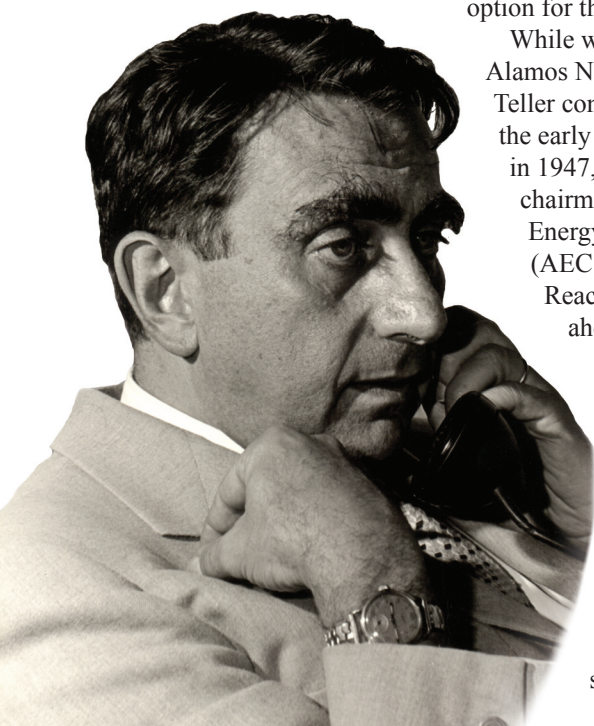
Teller also challenged researchers to design a foolproof reactor small enough for use in university research and in diagnostic and treatment procedures at hospitals. Teller's mandate was to "design a reactor so safe . . . that if it was started from its shut-down condition and all its control rods instantaneously removed, it would settle down to a steady level of operation without melting any of its fuel." That is, the reactor's safety features must be inherent—guaranteed by nature. Such a design would prevent a catastrophic accident even if the engineered safety features were bypassed.

In 1956, a team of distinguished physicists at General Atomics, including Frederic de Hoffmann, Freeman Dyson, and Ted Taylor, achieved this goal, designing a light-water reactor known as TRIGA® (Training, Research, Isotopes, General Atomics). The fuel rods in TRIGA reactors act as power regulators. In an emergency, they will shut down a reactor within a few thousandths of a second—faster than an engineered safety feature can respond. General Atomics installed the first TRIGA reactors in 1958. Today, more than 65 TRIGA facilities have been built in 24 countries. (For further information on TRIGA reactors, see triga.ga.com.) In the biographical memoir Dyson wrote on Teller for the National Academy of Sciences, he says, "I had one of my happiest experiences, working with Teller on the design of a safe nuclear reactor."

In 1957, Teller addressed the Joint AEC Weapons Laboratory Symposium on Nonmilitary Uses of Nuclear and Thermonuclear Explosions, appealing to the attendees to reach for new ideas in civilian nuclear applications. He thus planted the seeds that led to Project Plowshare—a national research program established to explore peaceful application of nuclear explosions, such as excavating mines and harbors or enhancing productivity of oil and gas wells.

Public concern about the environmental consequences of nuclear explosions brought an end to Project Plowshare. Nonetheless, the program's legacy is visible in many of the Laboratory's accomplishments, from an underground coal and oil gasification process to computer codes that model nuclear waste containment at the proposed Yucca Mountain repository.

Teller's enthusiasm for peaceful applications of nuclear power was predicated on the belief that sound solutions could be found to address four key issues: containing nuclear material in the event of an accident, simplifying a reactor's operation so that it is close to automatic, preventing the diversion of fuel for military use, and disposing of spent fuel safely and reliably. In 1972, he was





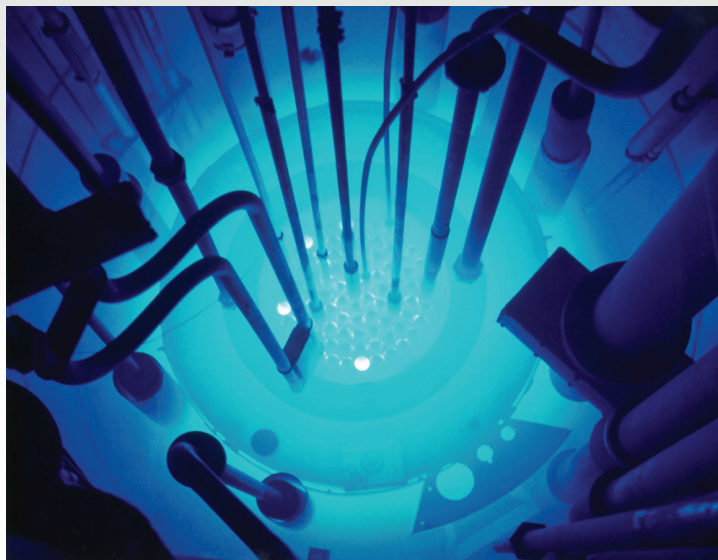
In 1962, Edward Teller received the Enrico Fermi Award from President John F. Kennedy (far right) in a White House ceremony attended by Glenn T. Seaborg (far left), chairman of the Atomic Energy Commission, and Teller's wife, Mici (second from right).

further intrigued when French physicists discovered evidence of a naturally occurring nuclear reactor in Oklo, Gabon. The reactor had burned itself out about 1.7 billion years ago after operating for 1 million years. Teller was certain this model from nature would lend answers to today's nuclear waste management questions.

In particular, Teller saw parallels between Oklo and the next generation of underground reactors being designed by Livermore scientists. The new fission reactors had no moving parts and could operate without human intervention for 30 years. Residual radioactivity would be sealed within the reactor's core and allowed to decay in place. An underground location would also limit the amount of radioactivity that could reach the surface in the event of an accident or earthquake.

Teller envisioned reactors sited 200 meters underground delivering 1,000 megawatts of power. Generally speaking, fission reactors, if widely adopted, could offset perhaps one-third of the projected increase in carbon emissions during the next century.

The 1979 reactor accident at Three Mile Island curtailed the nation's efforts to establish a thriving nuclear power program. However, in September, New Jersey-based NRG Energy filed an application with the Nuclear Regulatory Commission to build two advanced reactors in South Texas—the first such request in



In 1956, Teller challenged scientists at General Atomics to design an inherently safe nuclear reactor. That effort led to the TRIGA® reactor. This photograph looks down into the pool of a TRIGA Mark I reactor. (Reprinted courtesy of General Atomics, San Diego, California.)

more than 30 years. The Tennessee Valley Authority followed in October with an application to build a new plant at its Bellefonte site in Alabama.

Teller continued to think about nuclear power until the end of his life. In 2003, he wrote a paper with Livermore physicist Ralph Moir, putting forward new ideas on building thorium-burning reactors underground. This paper, Teller's last, appeared in *Nuclear Technology* in 2005.

Today, Lawrence Livermore is part of a Department of Energy collaboration developing a small, sealed, transportable, autonomous reactor (SSTAR) housed in a tamper-resistant container. SSTAR addresses the concerns of nuclear proliferation and the growing need for clean, reliable, and cost-effective energy. (See *S&TR*, July/August 2004, pp. 20–22.)

Teller maintained his optimism that, despite the obstacles, nuclear power could be used to further the good of humanity. He was confident that an improved reactor design could safely provide energy to developing nations and thus reduce the chasm that exists between poverty and wealth.

—Maurina S. Sherman

Key Words: fission; fusion; nuclear power; nuclear reactor; Project Plowshare; small, sealed, transportable, autonomous reactor (SSTAR); TRIGA® reactor.

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